

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

- 1 1. (Currently amended) A method for using a computer system to solve a
2 global inequality constrained optimization problem specified by a function f and a
3 set of inequality constraints $p_i(\mathbf{x}) \leq 0$ ($i=1, \dots, m$), wherein f and p_i are scalar
4 functions of a vector $\mathbf{x} = (x_1, x_2, x_3, \dots, x_n)$, the method comprising:
5 receiving a representation of the function f and the set of inequality
6 constraints at the computer system;
7 storing the representation in a memory within the computer system;
8 performing an interval inequality constrained global optimization process
9 to compute guaranteed bounds on a globally minimum value of the function $f(\mathbf{x})$
10 subject to the set of inequality constraints;
11 wherein performing the interval inequality constrained global optimization
12 process involves,
13 applying term consistency to a set of relations associated
14 with the global inequality constrained optimization problem over a
15 subbox \mathbf{X} , and excluding any portion of the subbox \mathbf{X} that violates
16 any of these relations,
17 applying box consistency to the set of relations associated
18 with the global inequality constrained optimization problem over
19 the subbox \mathbf{X} , and excluding any portion of the subbox \mathbf{X} that
20 violates any of these relations, and

21 performing an interval Newton step for the global
 22 inequality constrained optimization problem over the subbox \mathbf{X} to
 23 produce a resulting subbox \mathbf{Y} , wherein the point of expansion of
 24 the interval Newton step is a point \mathbf{x} ; and
 25 recording the guaranteed bounds in the computer system memory;
 26 wherein applying term consistency involves:
 27 symbolically manipulating an equation within the computer
 28 system to solve for a term, $g(\mathbf{x}'_j)$, thereby producing a modified
 29 equation $g(\mathbf{x}'_j) = h(\mathbf{x})$, wherein the term $g(\mathbf{x}'_j)$ can be analytically
 30 inverted to produce an inverse function $g^{-1}(\mathbf{y})$,
 31 substituting the subbox \mathbf{X} into the modified equation to
 32 produce the equation $g(\mathbf{X}'_j) = h(\mathbf{X})$,
 33 solving for $\mathbf{X}'_j = g^{-1}(h(\mathbf{X}))$, and
 34 intersecting \mathbf{X}'_j with the j -th element of the subbox \mathbf{X} to
 35 produce a new subbox \mathbf{X}^+ ,
 36 wherein the new subbox \mathbf{X}^+ contains all solutions of the
 37 equation within the subbox \mathbf{X} , and wherein the size of the new
 38 subbox \mathbf{X}^+ is less than or equal to the size of the subbox \mathbf{X} .

1 2. (Original) The method of claim 1, wherein applying term consistency to
 2 the set of relations involves applying term consistency to the set of inequality
 3 constraints $p_i(\mathbf{x}) \leq 0$ ($i=1, \dots, m$) over the subbox \mathbf{X} .

1 3. (Original) The method of claim 1, wherein applying box consistency to
 2 the set of relations involves applying box consistency to the set of inequality
 3 constraints $p_i(\mathbf{x}) \leq 0$ ($i=1, \dots, m$) over the subbox \mathbf{X} .

1 4. (Original) The method of claim 1,

2 wherein performing the interval inequality constrained global optimization
3 process involves,
4 keeping track of a smallest upper bound f_bar of the
5 function $f(\mathbf{x})$ at a feasible point \mathbf{x} ,
6 removing from consideration any subbox \mathbf{X} for which
7 $f(\mathbf{X}) > f_bar$;
8 wherein applying term consistency to the set of relations involves applying
9 term consistency to the f_bar inequality $f(\mathbf{x}) \leq f_bar$ over the subbox \mathbf{X} .

1 5. (Original) The method of claim 4, wherein applying box consistency to
2 the set of relations involves applying box consistency to the f_bar inequality
3 $f(\mathbf{x}) \leq f_bar$ over the subbox \mathbf{X} .

1 6. (Original) The method of claim 1, wherein if the subbox \mathbf{X} is strictly
2 feasible ($p_i(\mathbf{X}) < 0$ for all $i=1, \dots, n$), performing the interval inequality constrained
3 global optimization process involves:
4 determining a gradient $\mathbf{g}(\mathbf{x})$ of the function $f(\mathbf{x})$, wherein $\mathbf{g}(\mathbf{x})$ includes
5 components $g_i(\mathbf{x})$ ($i=1, \dots, n$);
6 removing from consideration any subbox for which $\mathbf{g}(\mathbf{x})$ is bounded away
7 from zero, thereby indicating that the subbox does not include an extremum of
8 $f(\mathbf{x})$; and
9 wherein applying term consistency to the set of relations involves applying
10 term consistency to each component $g_i(\mathbf{x})=0$ ($i=1, \dots, n$) of $\mathbf{g}(\mathbf{x})=\mathbf{0}$ over the subbox
11 \mathbf{X} .

1 7. (Original) The method of claim 6, wherein applying box consistency to
2 the set of relations involves applying box consistency to each component
3 $g_i(\mathbf{x})=0$ ($i=1, \dots, n$) of $\mathbf{g}(\mathbf{x})=\mathbf{0}$ over the subbox \mathbf{X} .

1 8. (Original) The method of claim 1, wherein if the subbox **X** is strictly
2 feasible ($p_i(\mathbf{X}) < 0$ for all $i=1, \dots, n$), performing the interval inequality constrained
3 global optimization process involves:
4 determining diagonal elements $H_{ii}(\mathbf{x})$ ($i=1, \dots, n$) of the Hessian of the
5 function $f(\mathbf{x})$;
6 removing from consideration any subbox for which a diagonal element
7 $H_{ii}(\mathbf{X})$ of the Hessian over the subbox **X** is always negative, indicating that the
8 function f is not convex over the subbox **X** and consequently does not contain a
9 global minimum within the subbox **X**; and
10 wherein applying term consistency to the set of relations involves applying
11 term consistency to each inequality $H_{ii}(\mathbf{x}) \geq 0$ ($i=1, \dots, n$) over the subbox **X**.

1 9. (Original) The method of claim 8, wherein applying box consistency to
2 the set of relations involves applying box consistency to each inequality
3 $H_{ii}(\mathbf{x}) \geq 0$ ($i=1, \dots, n$) over the subbox **X**.

1 10. (Original) The method of claim 1, wherein if the subbox **X** is strictly
2 feasible ($p_i(\mathbf{X}) < 0$ for all $i=1, \dots, n$), performing the interval Newton step involves:
3 computing the Jacobian $\mathbf{J}(\mathbf{x}, \mathbf{X})$ of the gradient of the function f evaluated
4 with respect to a point \mathbf{x} over the subbox **X**; and
5 computing an approximate inverse **B** of the center of $\mathbf{J}(\mathbf{x}, \mathbf{X})$,
6 using the approximate inverse **B** to analytically determine the system $\mathbf{Bg}(\mathbf{x})$,
7 wherein $\mathbf{g}(\mathbf{x})$ is the gradient of the function $f(\mathbf{x})$, and wherein $\mathbf{g}(\mathbf{x})$ includes
8 components $g_i(\mathbf{x})$ ($i=1, \dots, n$).

1 11. (Original) The method of claim 10, wherein applying term consistency
2 to the set of relations involves applying term consistency to each component
3 $(\mathbf{Bg}(\mathbf{x}))_i = 0$ ($i=1, \dots, n$) to solve for the variable x_i over the subbox **X**.

1 12. (Original) The method of claim 10, wherein applying box consistency
2 to the set of relations involves applying box consistency to each component
3 $(\mathbf{Bg}(\mathbf{x}))_i = 0$ ($i=1, \dots, n$) to solve for the variable x_i over the subbox \mathbf{X} .

1 13. (Original) The method of claim 1, wherein performing the interval
2 Newton step involves performing the Newton step on the John conditions.

1 14. (Original) The method of claim 1,
2 wherein performing the interval inequality constrained global optimization
3 process involves,
4 linearizing the set of inequality constraints to produce a set
5 of linear inequality constraints with interval coefficients that
6 enclose the nonlinear inequality constraints, and
7 preconditioning the set of linear inequality constraints
8 through additive linear combinations to produce a set of
9 preconditioned linear inequality constraints; and
10 wherein applying term consistency to the set of relations involves applying
11 term consistency to the set of preconditioned linear inequality constraints over the
12 subbox \mathbf{X} .

1 15. (Original) The method of claim 14, wherein applying box consistency
2 to the set of relations involves applying box consistency to the set of
3 preconditioned linear inequality constraints over the subbox \mathbf{X} .

1 16 (Canceled).

1 17. (Original) The method of claim 1, wherein performing the interval
2 Newton step involves:

3 computing $J(\mathbf{x}, \mathbf{X})$, wherein $J(\mathbf{x}, \mathbf{X})$ is the Jacobian of the function \mathbf{f}
4 evaluated as a function of \mathbf{x} over the subbox \mathbf{X} ; and
5 determining if $J(\mathbf{x}, \mathbf{X})$ is regular as a byproduct of solving for the subbox \mathbf{Y}
6 that contains values of \mathbf{y} that satisfy $\mathbf{M}(\mathbf{x}, \mathbf{X})(\mathbf{y} - \mathbf{x}) = \mathbf{r}(\mathbf{x})$, where
7 $\mathbf{M}(\mathbf{x}, \mathbf{X}) = \mathbf{B}J(\mathbf{x}, \mathbf{X})$, $\mathbf{r}(\mathbf{x}) = -\mathbf{B}\mathbf{f}(\mathbf{x})$, and \mathbf{B} is an approximate inverse of the center of
8 $J(\mathbf{x}, \mathbf{X})$.

1 18. (Currently amended) A computer-readable storage medium storing
2 instructions that when executed by a computer cause the computer to perform a
3 method for using a computer system to solve a global inequality constrained
4 optimization problem specified by a function f and a set of inequality constraints
5 $p_i(\mathbf{x}) \leq 0$ ($i=1, \dots, m$), wherein f and p_i are scalar functions of a vector $\mathbf{x} = (x_1, x_2,$
6 $x_3, \dots, x_n)$, the method comprising:
7 receiving a representation of the function f and the set of inequality
8 constraints at the computer system;
9 storing the representation in a memory within the computer system;
10 performing an interval inequality constrained global optimization process
11 to compute guaranteed bounds on a globally minimum value of the function $f(\mathbf{x})$
12 subject to the set of inequality constraints;
13 wherein performing the interval inequality constrained global optimization
14 process involves,
15 applying term consistency to a set of relations associated
16 with the global inequality constrained optimization problem over a
17 subbox \mathbf{X} , and excluding any portion of the subbox \mathbf{X} that violates
18 any of these relations,
19 applying box consistency to the set of relations associated
20 with the global inequality constrained optimization problem over

21 the subbox \mathbf{X} , and excluding any portion of the subbox \mathbf{X} that
 22 violates any of these relations, and
 23 performing an interval Newton step for the global
 24 inequality constrained optimization problem over the subbox \mathbf{X} to
 25 produce a resulting subbox \mathbf{Y} , wherein the point of expansion of
 26 the interval Newton step is a point \mathbf{x} ; and
 27 recording the guaranteed bounds in the computer system memory;
 28 wherein applying term consistency involves:
 29 symbolically manipulating an equation within the computer
 30 system to solve for a term, $g(\mathbf{x}'_j)$, thereby producing a modified
 31 equation $g(\mathbf{x}'_j) = h(\mathbf{x})$, wherein the term $g(\mathbf{x}'_j)$ can be analytically
 32 inverted to produce an inverse function $g^{-1}(\mathbf{y})$,
 33 substituting the subbox \mathbf{X} into the modified equation to
 34 produce the equation $g(\mathbf{X}'_j) = h(\mathbf{X})$,
 35 solving for $\mathbf{X}'_j = g^{-1}(h(\mathbf{X}))$, and
 36 intersecting \mathbf{X}'_j with the j -th element of the subbox \mathbf{X} to
 37 produce a new subbox \mathbf{X}^+ ,
 38 wherein the new subbox \mathbf{X}^+ contains all solutions of the
 39 equation within the subbox \mathbf{X} , and wherein the size of the new
 40 subbox \mathbf{X}^+ is less than or equal to the size of the subbox \mathbf{X} .

1 19. (Original) The computer-readable storage medium of claim 18,
 2 wherein applying term consistency to the set of relations involves applying term
 3 consistency to the set of inequality constraints $p_i(\mathbf{x}) \leq 0$ ($i=1, \dots, m$) over the
 4 subbox \mathbf{X} .

1 20. (Original) The computer-readable storage medium of claim 18,
 2 wherein applying box consistency to the set of relations involves applying box

3 consistency to the set of inequality constraints $p_i(\mathbf{x}) \leq 0$ ($i=1, \dots, m$) over the
4 subbox \mathbf{X} .

1 21. (Original) The computer-readable storage medium of claim 18,
2 wherein performing the interval inequality constrained global optimization
3 process involves,

4 keeping track of a smallest upper bound f_bar of the
5 function $f(\mathbf{x})$ at a feasible point \mathbf{x} ,

6 removing from consideration any subbox \mathbf{X} for which
7 $f(\mathbf{X}) > f_bar$;

8 wherein applying term consistency to the set of relations involves applying
9 term consistency to the f_bar inequality $f(\mathbf{x}) \leq f_bar$ over the subbox \mathbf{X} .

1 22. (Original) The computer-readable storage medium of claim 21,
2 wherein applying box consistency to the set of relations involves applying box
3 consistency to the f_bar inequality $f(\mathbf{x}) \leq f_bar$ over the subbox \mathbf{X} .

1 23. (Original) The computer-readable storage medium of claim 22,
2 wherein if the subbox \mathbf{X} is strictly feasible ($p_i(\mathbf{X}) < 0$ for all $i=1, \dots, n$), performing
3 the interval inequality constrained global optimization process involves:

4 determining a gradient $\mathbf{g}(\mathbf{x})$ of the function $f(\mathbf{x})$, wherein $\mathbf{g}(\mathbf{x})$ includes
5 components $g_i(\mathbf{x})$ ($i=1, \dots, n$);

6 removing from consideration any subbox for which $\mathbf{g}(\mathbf{x})$ is bounded away
7 from zero, thereby indicating that the subbox does not include an extremum of
8 $f(\mathbf{x})$; and

9 wherein applying term consistency to the set of relations involves applying
10 term consistency to each component $g_i(\mathbf{x})=0$ ($i=1, \dots, n$) of $\mathbf{g}(\mathbf{x})=\mathbf{0}$ over the subbox
11 \mathbf{X} .

1 24. (Original) The computer-readable storage medium of claim 23,
2 wherein applying box consistency to the set of relations involves applying box
3 consistency to each component $g_i(\mathbf{x})=0$ ($i=1, \dots, n$) of $\mathbf{g}(\mathbf{x})=\mathbf{0}$ over the subbox \mathbf{X} .

1 25. (Original) The computer-readable storage medium of claim 18,
2 wherein if the subbox \mathbf{X} is strictly feasible ($p_i(\mathbf{X}) < 0$ for all $i=1, \dots, n$), performing
3 the interval inequality constrained global optimization process involves:
4 determining diagonal elements $H_{ii}(\mathbf{x})$ ($i=1, \dots, n$) of the Hessian of the
5 function $f(\mathbf{x})$;
6 removing from consideration any subbox for which a diagonal element
7 $H_{ii}(\mathbf{X})$ of the Hessian over the subbox \mathbf{X} is always negative, indicating that the
8 function f is not convex over the subbox \mathbf{X} and consequently does not contain a
9 global minimum within the subbox \mathbf{X} ; and
10 wherein applying term consistency to the set of relations involves applying
11 term consistency to each inequality $H_{ii}(\mathbf{x}) \geq 0$ ($i=1, \dots, n$) over the subbox \mathbf{X} .

1 26. (Original) The computer-readable storage medium of claim 25,
2 wherein applying box consistency to the set of relations involves applying box
3 consistency to each inequality $H_{ii}(\mathbf{x}) \geq 0$ ($i=1, \dots, n$) over the subbox \mathbf{X} .

1 27. (Original) The computer-readable storage medium of claim 18,
2 wherein if the subbox \mathbf{X} is strictly feasible ($p_i(\mathbf{X}) < 0$ for all $i=1, \dots, n$), performing
3 the interval Newton step involves:
4 computing the Jacobian $\mathbf{J}(\mathbf{x}, \mathbf{X})$ of the gradient of the function f evaluated
5 with respect to a point \mathbf{x} over the subbox \mathbf{X} ; and
6 computing an approximate inverse \mathbf{B} of the center of $\mathbf{J}(\mathbf{x}, \mathbf{X})$,

7 using the approximate inverse \mathbf{B} to analytically determine the system $\mathbf{B}\mathbf{g}(\mathbf{x})$,
8 wherein $\mathbf{g}(\mathbf{x})$ is the gradient of the function $f(\mathbf{x})$, and wherein $\mathbf{g}(\mathbf{x})$ includes
9 components $g_i(\mathbf{x})$ ($i=1, \dots, n$).

1 28. (Original) The computer-readable storage medium of claim 27,
2 wherein applying term consistency to the set of relations involves applying term
3 consistency to each component $(\mathbf{B}\mathbf{g}(\mathbf{x}))_i = 0$ ($i=1, \dots, n$) to solve for the variable x_i
4 over the subbox \mathbf{X} .

1 29. (Original) The computer-readable storage medium of claim 27,
2 wherein applying box consistency to the set of relations involves applying box
3 consistency to each component $(\mathbf{B}\mathbf{g}(\mathbf{x}))_i = 0$ ($i=1, \dots, n$) to solve for the variable x_i
4 over the subbox \mathbf{X} .

1 30. (Original) The computer-readable storage medium of claim 18,
2 wherein performing the interval Newton step involves performing the interval
3 Newton step on the John conditions.

1 31. (Original) The computer-readable storage medium of claim 18,
2 wherein performing the interval inequality constrained global optimization
3 process involves,

4 linearizing the set of inequality constraints to produce a set
5 of linear inequality constraints with interval coefficients that
6 enclose the nonlinear inequality constraints, and
7 preconditioning the set of linear inequality constraints
8 through additive linear combinations to produce a set of
9 preconditioned linear inequality constraints; and

10 wherein applying term consistency to the set of relations involves applying
11 term consistency to the set of preconditioned linear inequality constraints over the
12 subbox **X**.

1 32. (Original) The computer-readable storage medium of claim 31,
2 wherein applying box consistency to the set of relations involves applying box
3 consistency to the set of preconditioned linear inequality constraints over the
4 subbox **X**.

1 33 (Canceled).

1 34. (Original) The computer-readable storage medium of claim 18,
2 wherein performing the interval Newton step involves:
3 computing $\mathbf{J}(\mathbf{x}, \mathbf{X})$, wherein $\mathbf{J}(\mathbf{x}, \mathbf{X})$ is the Jacobian of the function \mathbf{f}
4 evaluated as a function of \mathbf{x} over the subbox **X**; and
5 determining if $\mathbf{J}(\mathbf{x}, \mathbf{X})$ is regular as a byproduct of solving for the subbox **Y**
6 that contains values of \mathbf{y} that satisfy $\mathbf{M}(\mathbf{x}, \mathbf{X})(\mathbf{y} - \mathbf{x}) = \mathbf{r}(\mathbf{x})$, where
7 $\mathbf{M}(\mathbf{x}, \mathbf{X}) = \mathbf{B}\mathbf{J}(\mathbf{x}, \mathbf{X})$, $\mathbf{r}(\mathbf{x}) = -\mathbf{B}\mathbf{f}(\mathbf{x})$, and \mathbf{B} is an approximate inverse of the center of
8 $\mathbf{J}(\mathbf{x}, \mathbf{X})$.

1 35. (Currently amended) An apparatus that solves a global inequality
2 constrained optimization problem specified by a function f and a set of inequality
3 constraints $p_i(\mathbf{x}) \leq 0$ ($i=1, \dots, m$), wherein f and p_i are scalar functions of a vector
4 $\mathbf{x} = (x_1, x_2, x_3, \dots, x_n)$, the apparatus comprising:
5 a receiving mechanism that is configured to receive a representation of the
6 function f and the set of inequality constraints at the computer system;
7 a memory for storing the representation;

8 an interval global optimization mechanism that is configured to perform
9 an interval inequality constrained global optimization process to compute
10 guaranteed bounds on a globally minimum value of the function $f(\mathbf{x})$ subject to the
11 set of inequality constraints;

12 a term consistency mechanism within the interval global optimization
13 mechanism that is configured to apply term consistency to a set of relations
14 associated with the global inequality constrained optimization problem over a
15 subbox \mathbf{X} , and to exclude any portion of the subbox \mathbf{X} that violates any of these
16 relations,

17 a box consistency mechanism within the interval global optimization
18 mechanism that is configured to apply box consistency to the set of relations
19 associated with the global inequality constrained optimization problem over the
20 subbox \mathbf{X} , and to exclude any portion of the subbox \mathbf{X} that violates any of these
21 relations, and

22 an interval Newton mechanism within the interval global optimization
23 mechanism that is configured to perform an interval Newton step for the global
24 inequality constrained optimization problem over the subbox \mathbf{X} to produce a
25 resulting subbox \mathbf{Y} , wherein the point of expansion of the interval Newton step is
26 a point \mathbf{x} ; and

27 a recording mechanism that is configured to record the guaranteed bounds
28 in the computer system memory;

29 wherein the term consistency mechanism is configured to:

30 symbolically manipulate an equation within the computer system to solve
31 for a term, $g(\mathbf{x}'_j)$, thereby producing a modified equation $g(\mathbf{x}'_j) = h(\mathbf{x})$, wherein
32 the term $g(\mathbf{x}'_j)$ can be analytically inverted to produce an inverse function $g^{-1}(\mathbf{y})$;

33 substitute the subbox \mathbf{X} into the modified equation to produce the equation
34 $g(\mathbf{X}'_j) = h(\mathbf{X})$;

35 solve for $\mathbf{X}'_j = g^{-1}(h(\mathbf{X}))$; and

36 intersect X'_j with the j -th element of the subbox X to produce a new
37 subbox X^+ ;
38 wherein the new subbox X^+ contains all solutions of the equation within
39 the subbox X , and wherein the size of the new subbox X^+ is less than or equal to
40 the size of the subbox X .

1 36. (Original) The apparatus of claim 35, wherein the term consistency
2 mechanism is configured to apply term consistency to the set of inequality
3 constraints $p_i(\mathbf{x}) \leq 0$ ($i=1, \dots, m$) over the subbox X .

1 37. (Original) The apparatus of claim 35, wherein the box consistency
2 mechanism is configured to apply box consistency to the set of inequality
3 constraints $p_i(\mathbf{x}) \leq 0$ ($i=1, \dots, m$) over the subbox X .

1 38. (Original) The apparatus of claim 35,
2 wherein the interval global optimization mechanism is configured to,
3 keep track of a smallest upper bound f_bar of the function
4 $f(\mathbf{x})$ at a feasible point \mathbf{x} , and to
5 remove from consideration any subbox X for which
6 $f(X) > f_bar$;
7 wherein the term consistency mechanism is configured to apply term
8 consistency to the f_bar inequality $f(\mathbf{x}) \leq f_bar$ over the subbox X .

1 39. (Original) The apparatus of claim 38, wherein the box consistency
2 mechanism is configured to apply box consistency to the f_bar inequality
3 $f(\mathbf{x}) \leq f_bar$ over the subbox X .

1 40. (Original) The apparatus of claim 35, wherein if the subbox \mathbf{X} is
2 strictly feasible ($p_i(\mathbf{X}) < 0$ for all $i=1, \dots, n$), the interval global optimization
3 mechanism is configured to:
4 determine a gradient $\mathbf{g}(\mathbf{x})$ of the function $f(\mathbf{x})$, wherein $\mathbf{g}(\mathbf{x})$ includes
5 components $g_i(\mathbf{x})$ ($i=1, \dots, n$);
6 remove from consideration any subbox for which $\mathbf{g}(\mathbf{x})$ is bounded away
7 from zero, thereby indicating that the subbox does not include an extremum of
8 $f(\mathbf{x})$; and
9 the term consistency mechanism is configured to apply term consistency to
10 each component $g_i(\mathbf{x})=0$ ($i=1, \dots, n$) of $\mathbf{g}(\mathbf{x})=\mathbf{0}$ over the subbox \mathbf{X} .

1 41. (Original) The apparatus of claim 40, wherein the box consistency
2 mechanism is configured to apply box consistency to each component
3 $g_i(\mathbf{x})=0$ ($i=1, \dots, n$) of $\mathbf{g}(\mathbf{x})=\mathbf{0}$ over the subbox \mathbf{X} .

1 42. (Original) The apparatus of claim 35, wherein if the subbox \mathbf{X} is
2 strictly feasible ($p_i(\mathbf{X}) < 0$ for all $i=1, \dots, n$), the interval global optimization
3 mechanism is configured to:
4 determine diagonal elements $H_{ii}(\mathbf{x})$ ($i=1, \dots, n$) of the Hessian of the
5 function $f(\mathbf{x})$;
6 remove from consideration any subbox for which a diagonal element
7 $H_{ii}(\mathbf{X})$ of the Hessian over the subbox \mathbf{X} is always negative, indicating that the
8 function f is not convex over the subbox \mathbf{X} and consequently does not contain a
9 global minimum within the subbox \mathbf{X} ; and
10 the term consistency mechanism is configured to apply term consistency to
11 each inequality $H_{ii}(\mathbf{x}) \geq 0$ ($i=1, \dots, n$) over the subbox \mathbf{X} .

1 43. (Original) The apparatus of claim 42, wherein the box consistency
2 mechanism is configured to apply box consistency to each inequality
3 $H_{ii}(\mathbf{x}) \geq 0$ ($i=1, \dots, n$) over the subbox \mathbf{X} .

1 44. (Original) The apparatus of claim 35, wherein if the subbox \mathbf{X} is
2 strictly feasible ($p_i(\mathbf{X}) < 0$ for all $i=1, \dots, n$), the interval global optimization
3 mechanism is configured to perform the interval Newton step by:
4 computing the Jacobian $\mathbf{J}(\mathbf{x}, \mathbf{X})$ of the gradient of the function f evaluated
5 with respect to a point \mathbf{x} over the subbox \mathbf{X} ; and
6 computing an approximate inverse \mathbf{B} of the center of $\mathbf{J}(\mathbf{x}, \mathbf{X})$,
7 using the approximate inverse \mathbf{B} to analytically determine the system
8 $\mathbf{B}\mathbf{g}(\mathbf{x})$, wherein $\mathbf{g}(\mathbf{x})$ is the gradient of the function $f(\mathbf{x})$, and wherein $\mathbf{g}(\mathbf{x})$ includes
9 components $g_i(\mathbf{x})$ ($i=1, \dots, n$).

1 45. (Original) The apparatus of claim 44, the term consistency mechanism
2 is configured to apply term consistency to each component $(\mathbf{B}\mathbf{g}(\mathbf{x}))_i = 0$ ($i=1, \dots, n$)
3 to solve for the variable x_i over the subbox \mathbf{X} .

1 46. (Original) The apparatus of claim 44, the box consistency mechanism
2 is configured to apply box consistency to each component $(\mathbf{B}\mathbf{g}(\mathbf{x}))_i = 0$ ($i=1, \dots, n$)
3 to solve for the variable x_i over the subbox \mathbf{X} .

1 47. (Original) The apparatus of claim 35, wherein the interval Newton
2 mechanism is configured to perform the Newton step on the John conditions.

1 48. (Original) The apparatus of claim 35,
2 wherein the interval global optimization mechanism is configured to:

3 linearize the set of inequality constraints to produce a set of
4 linear inequality constraints with interval coefficients that enclose
5 the nonlinear inequality constraints, and to
6 precondition the set of linear inequality constraints through
7 additive linear combinations to produce a set of preconditioned
8 linear inequality constraints; and
9 wherein the term consistency mechanism is configured to apply term
10 consistency to the set of preconditioned linear inequality constraints over the
11 subbox **X**.

1 49. (Original) The apparatus of claim 48, wherein the box consistency
2 mechanism is configured to apply box consistency to the set of preconditioned
3 linear inequality constraints over the subbox **X**.

1 50 (Canceled).

1 51. (Original) The apparatus of claim 35, wherein the interval Newton
2 mechanism is configured to:
3 compute $\mathbf{J}(\mathbf{x}, \mathbf{X})$, wherein $\mathbf{J}(\mathbf{x}, \mathbf{X})$ is the Jacobian of the function \mathbf{f} evaluated
4 as a function of \mathbf{x} over the subbox **X**; and to
5 determine if $\mathbf{J}(\mathbf{x}, \mathbf{X})$ is regular as a byproduct of solving for the subbox **Y**
6 that contains values of \mathbf{y} that satisfy $\mathbf{M}(\mathbf{x}, \mathbf{X})(\mathbf{y} - \mathbf{x}) = \mathbf{r}(\mathbf{x})$, where
7 $\mathbf{M}(\mathbf{x}, \mathbf{X}) = \mathbf{B}\mathbf{J}(\mathbf{x}, \mathbf{X})$, $\mathbf{r}(\mathbf{x}) = -\mathbf{B}\mathbf{f}(\mathbf{x})$, and \mathbf{B} is an approximate inverse of the center of
8 $\mathbf{J}(\mathbf{x}, \mathbf{X})$.